



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

## Airborne Cloud Computing Environment (ACCE)

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### What is ACCE?

- ACCE is JPL's internal investment to improve the return on airborne missions.
  - *Improve development performance of the data system*
  - *Improve return on the captured science data*
- The investment is to **develop a common science data system capability for airborne instruments** that encompasses the end-to-end lifecycle covering planning, provisioning of data system capabilities, and support for scientific analysis in order to improve the **quality, cost effectiveness, and capabilities** to enable new scientific discovery and research in earth observation.



## Why ACCE?

- Currently, no coordinated data system effort to collect, process, distribute and archive data from airborne missions
- Data systems are not architected for use across several instruments; limited data sharing
- Limited infrastructure for developing, testing and integrating algorithms
- Each PI team develops their own “one off” leading to cost and performance challenges

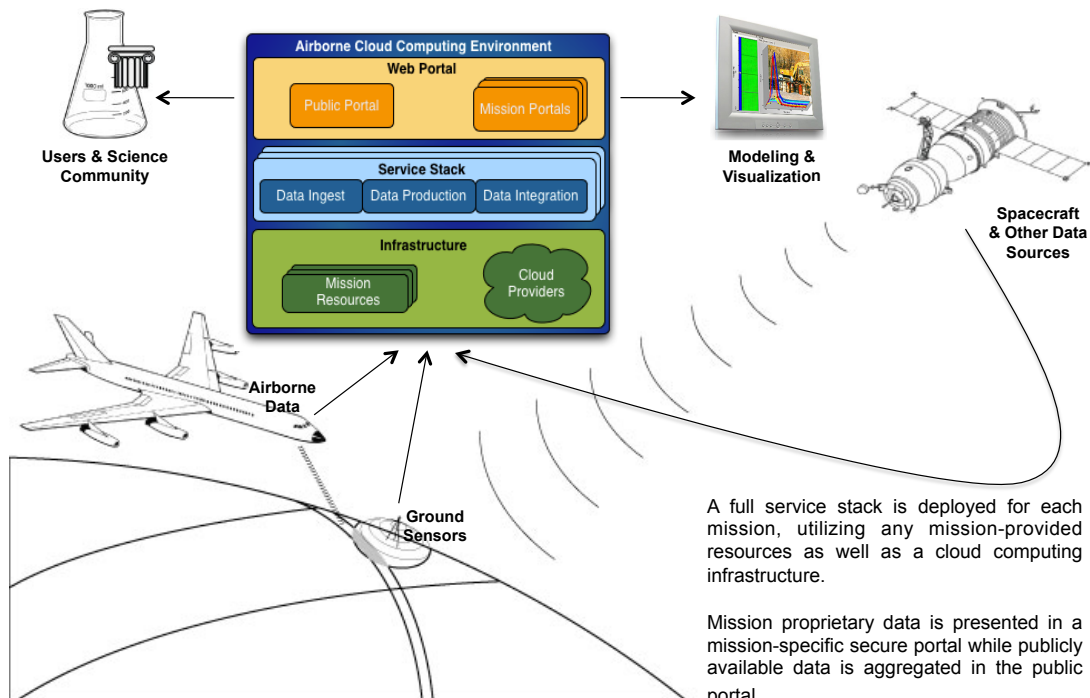


## Approach

- Develop an Airborne Science Data System
  - *Capture, process, archive and distribute airborne instrument data*
  - *Leverage existing product line software at JPL being used for OCO, SMAP, NPP Sounder PEATE, EDRN, VODC, ...*
    - Utilizing the full suite of CAS-related **Apache OODT** components
  - *Provide options to either host PI data system instances or allow them to deploy their own instance*
- Deliver shared services as part of a “cloud” strategy enabling:
  - *PI integration and access to airborne data system services from their own facilities and labs (processing, data management, distribution, etc.)*
  - *Use of both internal and external cloud services*



## Data System Concept



A full service stack is deployed for each mission, utilizing any mission-provided resources as well as a cloud computing infrastructure.

Mission proprietary data is presented in a mission-specific secure portal while publicly available data is aggregated in the public portal.

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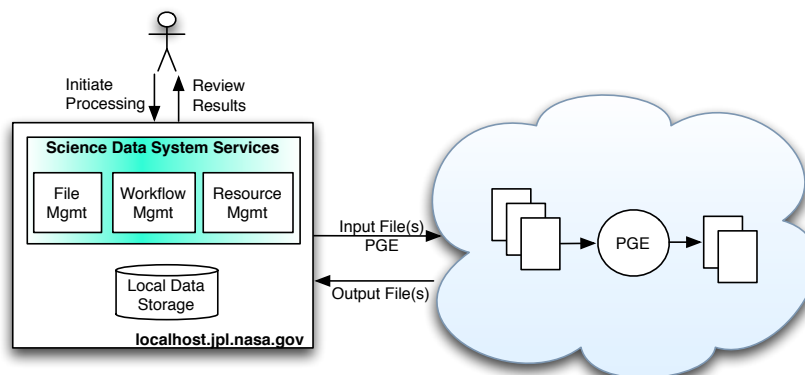
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## Cloud Trade Study

- Initiated a trade study of cloud solutions to explore the benefits of performing science data processing for airborne missions in the cloud.

*A typical science data processing job (PGE) is an executable that performs a task on one or more inputs to produce one or more outputs.*



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## Cloud Challenges

- Host Environment
  - *Each PGE is compiled for a specific OS platform, but not all PGEs are compiled on the same platform*
  - *Dynamically linked third party libraries must be available*
    - May require locally available licenses
  - *Sufficient CPU and memory available on-demand*
  - *Sufficient storage available on-demand*
- Security
  - *ITAR-compliance is required for handling ITAR-sensitive data*
- Network
  - *File transfer rates for large input and output files*
  - *Ability to communicate through the JPL Firewall*



## Technologies Explored

- Apache's Object Oriented Data Technology's (OODT) Catalog and Archive Service (CAS) components
  - *Provides basic services for File, Workflow and Resource management.*
- Amazon EC2/S3 (public/commercial cloud)
  - *Elastic compute resources and on-demand storage*
- Eucalyptus (private cloud infrastructure)
  - *Infrastructure software for establishing a private cloud*
- Hadoop – Distributed File System (DFS) and Map/Reduce
  - *Increased processing performance on large data sets*



## Trade Study Analysis

	Trade Dimension	Mission Maintained	Private Cloud	Commercial Cloud
Performance	Processor Speed	High <sup>§</sup> /Med <sup>§</sup> /Low	Low	High*/Med*/Low
	Interconnect Speed	High <sup>§</sup> /Med <sup>§</sup> /Low	Low	High*/Low
	Transfer Speed	Med-High	Med-High	Low-Med
Key Considerations	ITAR Concerns	No	No	Yes
	Offsite Data Backup	No	No	Yes
	Growth/Bursting Potential	Step-wise capitol investment	Managed growth, minimal bursting	Linear scaling, high burst capability
Costs	Upfront Costs (Processing)	Capitol investment	-	-
	Ongoing Costs (Processing)	SA Support, Maintenance, HW Replenishment	Pay-by-drink	Pay-by-drink
	Upfront Costs (Disk)	Capitol investment	-	-
	Ongoing Costs (Disk)	SA Support, Maintenance, HW Replenishment	Pay-by-drink	Pay-by-drink

<sup>§</sup> Increased Upfront Cost      \* Increased Ongoing Costs



## Trade Study Summary

- Cloud storage benefits vary depending on the provider
- Cloud computing (public or private) decreases processing cost
  - *No investment in capital required (upfront or refresh costs)*
  - *Pay only for what you use*
- Possible limiting factors for public cloud viability
  - *Support for ITAR-sensitive data*
  - *Data transfer rates between JPL and the cloud*
  - *Access through JPL firewall*



## Partnering with CARVE

- The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) is the first operational customer/partner for ACCE.
- Their Fourier Transform Spectrometer (FTS) instrument will produce over 700K soundings over the life of the mission (3 years).
- Their hardware cost was driven by the requirement for Level 2 Full Physics processing.
- Their analysis concluded the following processing costs:
  - 481K - *Purchase and operation of a cluster-based system*
  - 196K - *Utilize Amazon EC2*
- Therefore the FTS Level 2 Full Physics processing will be performed on the cloud.
  - *All other processing performed locally on commodity hardware with the ACCE software stack deployed in the CARVE environment.*



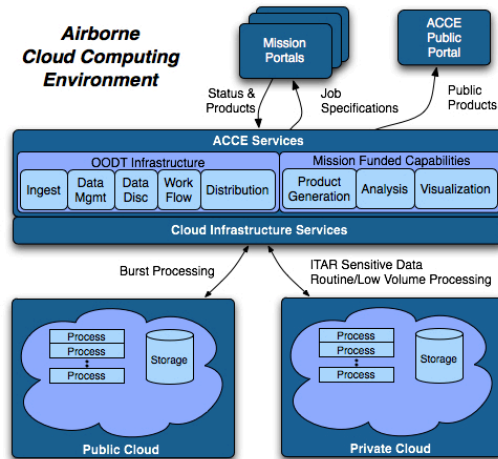
## Current Efforts with Amazon

- JPL's preferred public cloud provider is Amazon.
  - *Don't have too many details on the CIO office's decision but contracts are in place to facilitate charging JPL project accounts.*
- Amazon is making an effort to address the "limiting factors".
  - *An "ITAR Region" is planned for Fall 2011.*
  - *Continued benchmarking and optimization has demonstrated increased data transfer rates, 250 - 400 mbps.*
  - *Their Virtual Private Cloud (VPC) solution alleviates JPL firewall issues.*
- Working with the developers of Polyphony to provide the ACCE interface to Amazon.
  - *Polyphony is a workflow orchestration framework for cloud computing.*
  - *The framework is not limited to Amazon and will allow ACCE to interface with other cloud solutions.*
  - *More information on Polyphony:*
    - <http://usrp.usra.edu/technicalPapers/jpl/Rossi.pdf>
    - <http://aws.amazon.com/solutions/case-studies/nasa-jpl/>



## Wrap Up

- Although Amazon is JPL and CARVE's choice, ACCE is looking into other cloud and computing solutions.
  - *Pleiades Supercomputer*
  - *NEBULA Cloud Computing Platform*
- Investment to date has allowed ACCE to standardize deployment of the service stack and a generalized portal.
- The last year of ACCE's internal funding will focus on new portal features and cloud integration.



## Questions/Comments

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